Plausible Effects of Climate Change to Alaska Parks in the 21st Century.

INSTRUCTIONS: Each participant is invited to rank the potential effects to park resources, assets, operations and other values (e.g., sustainable communities). We're looking for input from multiple people. Rank factors in any parks for which you have good information. Skip boxes, rows, and columns where you don't have enough information to make a determination. Place an "H" in the box where you feel that there could be highly consequential impacts to the park as a result of this effect. Use "L " where the effects appear implausible, negligible or of low consequence (for example sea level rise is not a plausible risk for inland areas at high altitude). Use "M" if the consequences and likelihood of happening both seem intermediate. You can insert comments to provide more detail about location and effects.

Sector	**Subsector**	**Potential Effects to Resources, Operations, and People**	**Affected Arctic Alaska Parks**				
			KEFJ	LACL	KATM	ANIA	ALAG
Atmosphere	Greenhouse gases	**Shrub expansion into tundra, new vegetation in deglaciated areas, and increased woody vegetation overall sequesters carbon.**	H	H	MHH	LMM	MMM
		Drought stress reduces carbon sequestration capacity of boreal forests.	M	L	LMM	LLL	LLL
		More forest conversion to agricultural uses and increased logging' of dead wood increases greenhouse gas emissions from soil in Alaska.	ML	M	LLL	LLL	LLL
		Permafrost thaw and fires release additional greenhouse gases (e.g., CO_2 and methane) from tundra and forests. Areas that previously served as carbon sinks begin releasing more greenhouse gases than they sequester.	L	M	LLL	LLL	LLL
		Ocean ecosystems may become increasingly saturated with CO_2 and take up less CO_2 from the atmosphere, leading to more rapid CO_2 build up in the atmosphere.	LH	L	LLL	LLL	LLL
		Deliberate biological and geological sequestration may be implemented on federal-owned and other lands	L	L	LLL	LLL	LLL

Comment [RB1]: Logging Native Corps Lands?

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			KEFJ	LACL	KATM	ANIA	ALAG
	Air temperature	**Air temperature increases** at an average rate of 1°F (0.56°C) per decade for national parks in Alaska. Warming is especially pronounced for the northernmost parks and during the historically coldest times of the year.	MH	M	MHH	LHH	MHH
		Average annual temperatures shift from below freezing to above freezing in several parks (BELA, DENA, YUCH), changing the freeze/thaw balance.	ML	M	MHH	LMM	MMM
	Precipitation	**Average annual precipitation increases in all NPS areas in Alaska** through the mid- to late-21st Century. Relative proportions of moisture deposited as snow, ice or rain change as temperature increases.	H	H	M/HH MM	MHMM	M/HH MM
		Many areas will experience drying conditions despite increased precipitation, due to higher temperature and increased rates of evapotranspiration.	MH	H	MMM	LLL	MLL
		More freezing rain events affect foraging success and survival of wildlife, travel safety, and utility transmission.	H	H	MHLL	MHLL	MHLL
		Avalanche hazards increase in some areas with rising precipitation and rising winter temperatures.	H	H	MLL	LLL	LLL
		Avalanche hazards decline in some area with decreasing snowfall below 3,000 feet (e.g., Juneau).	L	L	MLL	LLL	LLL
	Stormy weather	**Lightning and lightning-ignited fires continue to increase.**	LM	M	MMM	LLL	MLL
		Storm and wave impacts	ML	M	MLL	MLL	LLL
	Air quality	**More smoke from longer and more intense fire** seasons results in seasonal and locally-severe smoke events, with respiratory and other associated health risks to populations.	M	M	LMM	LLL	LMM
	Atmospheric contaminants	**Shifting contaminant distribution.** Dieldrin, p,p'-DDE, and mercury concentrations in some NPS areas in Alaska exceed established human health thresholds for humans, fish and mammals. Consumption	LM	L	LLL	LLL	LLL

Comment [RB2]: In more northern parts of these parks

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			KEFJ	LACL	KATM	ANIA	ALAG
		advisories may be warranted to reduce or curtail consumption of affected species and age/size classes, especially for children and women of child bearing age.					
		Increased contaminant bioavailability. Fugitive dust releases from mining operations near the NOAT, and transportation of ore concentrates through CAKR have resulted in elevated lead, cadmium, and zinc levels in plants and small animals in CAKR and in plants in the NOAT. Increased bioavailability of zinc dust (a known mossicide) with changing climatic conditions could markedly alter vegetation communities over large areas, and affect other species, subsistence use patterns and human health.	L	M	LMM	LLL	LMM
Cryosphere	Ice/Snow	**Snow and ice season is shorter with later onset of freeze-up and snowfalls and earlier spring snowmelt and ice breakup in Alaska.**	H	H	MHH	MHH	MMM
		Arctic snow cover declines, with higher average air temperatures, earlier spring thaw, and cryoconite deposition (atmospheric soot and dust)**.**	L		LL	LL	LL
		Lack of snow cover leads to deeper freezing of water in the ground or river beds resulting in more aufeis (overflow ice) on rivers and lakes and formations of pingos and yedomas on land.	L		LL	LL	LL
		Most glaciers diminish as warming continues.	H	H	HHH	LLL	LLL
		Glacial outwash (silt, sand, gravel) accumulates as glaciers melt, affecting aquatic productivity in both positive and negative ways and forming deposits that can complicate shallow water navigation.	H	H	MLL	LLL	LLL
		Glacial lakes and glacially dammed lakes fail with increasing but still unpredictable frequency, putting park staff, residents, and visitors at risk of flash floods and debris flows.	H	H	MLL	LLL	LLL
		Surging glaciers could block rivers and fjords resulting in severe	L	L	LLL	LLL	LLL

Comment [RB3]: Pebble Mine and others in region?

Comment [RB4]: Increased mid-winter thaws

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			KEFJ	LACL	KATM	ANIA	ALAG
		flooding in some locations. When a surging glacier blocks an existing drainage basin, it can result in potentially dangerous overflow and flooding events. Hubbard and Tweedsmuir Glaciers, near WRST and GLBA respectively, are among those recognized for severe flood hazards.					
		Undiscovered cultural resources are exposed as perennial snow and ice patches melt and recede.	LM	H	LMM	LMM	LLL
	Sea Ice	**Shorter sea ice season, with less and thinner ice** complicates travel over ice, while easing boat travel through ice. Lack of sea ice in Spring-Fall impacts ecosystems (negatively for marine mammals/positively for some fish species), impacts subsistence access, increases risk and costs for marine mammal hunters. Adds energy to storm surges which increases erosion with high economic costs for community relocation.	ML	M	LLL	LLL	L
		Seasonal reductions in Arctic sea ice enable more marine transportation and shipping accidents. As passenger and cargo traffic increases, the potential for accidents and the risk of spills contaminating NPS coastal resources increases.	M		LL	LL	LL
	Ice Roads	**Reduced winter transportation opportunities on frozen tundra** affect opportunities for natural resource development, access to subsistence sites, and travel between villages, spurring discussion of alternative transportation routes and easements.	L	M	MLL	LLL	LLL
	Permafrost	**Mercury and other pollutants are released into the aquatic environment** as the permafrost thaws, increasing contaminant exposure for wildlife and humans that rely on the marine ecosystem for food.	ML	M	LLL	LLL	LLL
Hydrosphere	Sea level	**Some coastal villages rapidly lose ground relative to sea level**, such as Newtok in the Yukon Kuskokwim Delta, Shishmaref and Kivalina in	L	L	LLL	LLL	LLL

Comment [RB5]: Equipment transport over lake ice curtailed

Comment [RB6]: Little permafrost in SWAN

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			KEFJ	LACL	KATM	ANIA	ALAG
		Northwest Alaska. Erosion and subsidence are complicating factors.					
		Global average sea level is predicted to rise an additional 1-6 feet by the end of the 21st Century. However, regional trends in relative sea level vary widely with the effects of isostatic rebound, subsidence, warming, sediment deposition, etc.	LM	L	LLL	LLL	LLL
		In general Alaska's coasts are less vulnerable to flooding caused by global sea level rise than are equatorial regions. Recently glaciated coasts appear to be maintaining equilibrium or rising relative to sea level, partly because of post-glacial rebound. [ii]	ML	L	LLL	LLL	LLL
	Marine	**Increasing sea surface temperature affects ice-dependant species and their foods,** distribution and population dynamics of fish, seabird, and wildlife species.	M	L	LLL	LLL	LLL
		Falling global phytoplankton concentration could reduce ocean productivity and CO_2 sequestration. Phytoplankton has declined at a average rate of ~1% of the global average per year over the last century. These fluctuations are strongly correlated with climate indices and sea surface temperature.	MH	M	MLL	LLL	LLL
		Freshwater influx from thawing glaciers dilutes marine waters, lowering salinity, calcium saturation, and pH, and stressing sensitive zooplankton, corals, mollusk s and other species in some areas.	M/H	L	L/MLL	LLL	LLL
		Toxic marine algae and shellfish poisoning affects humans and marine mammals (e.g., PSP, ASP). Outbreaks are attributed to seasonal changes in coastal water temperature, nutrient enrichment, salinity, and ballast water discharge.	H	H	HLL	HLL	LLL
		Ocean acidification affects plankton and benthic calcifying fauna (e.g., bivalves and echinoderms) in the Arctic more strongly than at lower latitudes, affecting food sources of fish, marine mammals such as	H	M/H	M/HMM	MMM	LLL

Comment [RB7]: TECTONICS IS A BIGGER DRIVER HERE

Comment [RB8]: Harbor seals in fjords

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			KEFJ	LACL	KATM	ANIA	ALAG
		walrus and gray whales, plankton feeding birds, and potentially the composition of the ecosystem.					
		Ocean acidification reduces sound absorption. Based on current projections of future pH values for the oceans, a decrease in sound absorption of 40% is expected by mid-century.	MH	L	MLL	LLL	LLL
	Estuarine	**Coastal erosion and sea level rise increase the frequency of saltwater flooding in some coastal areas**, infiltrating freshwater coastal lagoons, marshes, and groundwater with salt.	M	M	MLL	MLL	LLL
		Some shallow water areas to convert to terrestrial ecosystems with post-glacial rebound (e.g., GLBA).	M	L	LLL	LLL	LLL
	Freshwater	**Stream flows from by melting glaciers increase and then decrease over time.** As glaciers are diminished in extent, the quantity of water they store is also greatly reduced. Even if annual precipitation remains constant, seasonal flows are likely to change substantially.	H	H	M/HH H	LLL	LLL
		Ponds shrink as thermokarst drainage occurs in some permafrost areas. Others form as ground ice thaws and ground surface subsides, but many drain through surface or subsurface discharge as thaw depth increases.	L	L	LLL	LLL	LLL
		Drainage from thawing waste and sewage dumps contaminates rural water supplies. Two-thirds of Alaska's village residents still do not have access to sanitary means of sewage disposal or adequate supplies of safe water.	L	L	LLL	LLL	LLL
	Groundwater	**Ground water supplies that depend on seasonal glacial recharge become less predictable.**	MH	M	L/MLL	LLL	LLL
Lithosphere	Ground level	**Ground level continues to rise in some recently de-glaciated areas.** Glacier mass depresses the land beneath them. When glaciers melt, the land rises or exhibits isostatic rebound, up to 1.2 inches per year	M	M	LLL	LLL	LLL

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		around GLBA.					
		Shorelines and land boundaries shift with rebound. High water lines change with rebound. Water edges may shift away from property boundaries based on fixed survey points.	M	L	LLL	LLL	LLL
	Ground stability	**More constructed assets fail or require repairs.** Many locations in Alaska that are underlain by permafrost are susceptible to thaw damage. Modeling by University of Alaska researchers suggests that projected climate changes could raise future infrastructure costs about 10%.	L	L	LLL	LLL	LLL
		Landslides and mud flows increase on steep slopes. Rapid glacial retreat and permafrost thaw also leave steep and unstable slopes in valleys and fjords. Landslides and mudflows will occur widely in some parks.	H	H	MLL	LLL	LLL
		Earthquake activity increases in recently deglaciated areas. Glaciers melting and the associated isostatic rebound of the land may increase the frequency of earthquakes.	MH	M	LLL	LLL	LLL
		Large and small tsunamis could result from collapse of unstable slopes in fjords (e.g., glacial moraine and sediment deposits, both above and below water). Earthquakes have previously triggered slope collapse and tsunami events in Alaska.	H	L	MLL	LLL	LLL
		Coastal erosion claims both natural and cultural resources and constructed assets. Coastal erosion is proceeding at an average of 20” (0.5 m)/year in some areas of CAKR and in BELA. Coasts in some communities are eroding much more rapidly than this (tens of meters per year). Some constructed assets, historic and prehistoric sites will no longer be sustainable and will require triage to determine which to repair, relocate, document, or abandon. Large areas of Alaska’s coastal parks lack needed surveys for archaeological sites.	LM	L	MLL	LLL	LLL

Comment [RB9]: Mink Island site protection

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		Burials and other human remains are exposed in some areas as cultural sites thaw and erode due to changing hydrology, ice, snow, and permafrost thaw.	L	M	MLL	MLL	LLL
	Soil	**Soil moisture declines** due to rising soil temperature, increased evapotranspiration, thawing permafrost, and natural drainage.	L	M	LLL	LMM	LLL
	Rock and gravel	**Demand for rubble and rock increases**, as it is required for repairs and new construction, roads, and community relocation.	MH	L	MLL	LLL	LLL
Biosphere	General						
		Ecological "tipping points" are likely to result in rapid change, when conditions exceed physical or physiological thresholds (e.g., thaw, drought, water temperature).	H		MM	LL	LL
	Vegetation	**Increased growing season length**. Modeling predicts that the mean number of frost free days for the Boreal and Arctic bioregion will increase between 20 and 40 days by the end of the century.	MH	M	MMM	MMM	MMM M
		Increased agricultural production in Alaska. A longer growing season and Alaska's abundant summer sunlight provide new agricultural opportunities in some areas.	L	L	LLL	LLL	LLL
		Large-scale landcover changes occur over periods of years to decades. Some terrestrial vegetation models suggest potential for large-scale conversion of low tundra to shrubs, then to conifers, and from conifers to deciduous forests, or perhaps to grass. Other models indicate increasing lichen, decreased sedges, and increases to deciduous and evergreen shrubs.	HL	H	HHH	M	MLL
		Vegetation expands into deglaciated coastal areas, but less markedly into higher elevation areas.	H	M	LLL	LLL	LLL
		Tree species and vegetation classes shift as species typical of lower altitudes and latitudes expand into higher areas.	H	H	MMM	MMM	LMM

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		Mountain and arctic ecosystems could change substantially within 50 years, and conditions become unsuited for some native species. **Some rare species could become endangered and endangered plants species may go extinct as conditions change.**	H	H	MMM	MLL	LLL
		Drought stress affects boreal forests as evapotranspiration increases with warmer/drier summers leading to reduced tree growth, reduced carbon sequestration, and increased disturbance from fires and insect outbreaks.	LH	MH	LMM	LLL	LLL
		Atypical outbreaks of forest pests and plant diseases occur more widely, increasing fire hazards and hastening decline of native and familiar species.	H	H	H/MH H	LLL	MLL
		Invasive exotic species and native species from other areas expand into parks. It becomes easier for invasive species that are already adapted to such conditions, to survive, reproduce and expand into available habitat as native species become increasingly stressed by changing conditions such as rising temperature and declining soil moisture.	MH	M	MMM	LLL	LLL
		Shrubs and trees expand further into tundra primarily along hillsides and valleys. Some scenic tundra vistas become thick with deciduous trees and shrubs, obscuring wildlife observations from visitor centers and park roads.	ML	M	HLL	LLL	MLL
		Black spruce may expand or contract, expanding under warming conditions coupled with increasing fire interval – or contracting as underlying permafrost soils thaw and fire frequency increases.	L	M	MMM	LLL	MLL
		Mature forests and "old growth" decline, as a result of changing soil moisture, drought, insects, disease, and fire.	H	H	MLL	LLL	LLL
		Mature yellow cedars decline across southeast Alaska, possibly due	L				

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		to lack of late season snow pack that helps to insulate the roots and protect them from spring freezes.					
	Fire	**Fire increases in boreal and tundra ecosystems.** Model simulations show a warming climate leads to slightly more fires and much larger fires, as well as expansion of forest into previously treeless tundra. Flammability increases rapidly in direct response to climate warming and more gradually in response to climate-induced vegetation changes.	MHM	H	MHHH	LHMM	MHMM
		Wildland fire hazards increase, affecting communities and isolated property owners.	LM	M	MMM	LLL	MMM
		Fire-related landcover and soil changes include vegetation population shifts, major permafrost thawing, soil decomposition, and surface subsidence.	L	M	MMM	LLL	MLL
	Wildlife - General	**Changes to the terrestrial and aquatic species compositions in parks and refuges occur as ranges shift**, contract, or expand. Rare species and/or communities may become further at risk, and additional species could become rare. Some early-succession species will benefit from changes.	MH	M	LLL	LLL	LLL
		Parks and refuges may not be able to meet their mandate of protecting current species within their boundaries, or in the case of some refuges, the species for whose habitat protection they were designed. While some wildlife may be able to move northward or to higher elevations to escape some effects of climate change, federal boundaries are static.	HHL	MH	MHLL	MHLL	LHLL
		Changes in terrestrial and marine wildlife distributions affect visitor experiences and subsistence throughout the region.	H	M	MLL	MLL	MLL
		Some species suffer severe losses. An analysis of potential climate change impacts on mammalian species in U.S. national parks indicates	M/H	H	M/HLL	MLL	MLL

Comment [RB10]: If salmon populations collapse, then huge changes in species populations will occur

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		that on average about 8% of current mammalian species diversity may be lost. The greatest losses across all parks occurred in rodent species (44%), bats (22%), and carnivores (19%).					
		Animals and plants will expand into landscapes vacated by glacial ice and utilize new alpine lakes after ice is gone	H	H	MLL	LLL	LLL
		Predator-prey relationships may change in unexpected ways.	H	H	HLL	MLL	MLL
		Migratory routes and destinations will change for some species (e.g., wetlands, open tundra, snow patches).	LH	L	LLL	LLL	LLL
	Wildlife - Birds	**Arctic and alpine breeding birds' breeding habitats will be reduced** or eliminated as trees and shrubs encroach on areas currently occupied by tundra. 72% of Arctic and alpine birds are considered moderately or highly vulnerable to the impacts of climate change.	ML	M	MMM	LMM	LMM
		Kittlitz's murrelet populations continue to decline as glacial retreat results in the loss of important nesting and foraging habitats.	H	M	M/LLL	LLL	LLL
		Boreal forest birds expand into the arctic as climate changes, causing new avian communities to develop.	L		LL	LL	LL
		Millions of geese could lose almost half of their breeding habitat due to a predicted change in vegetation in the Arctic from tundra to taiga and boreal forest.	HL	H	HLL	HLL	HLL
		Waterfowl shifts occur as coastal ponds become more salty in some areas.	LH	MH	LHLL	LHLL	LHLL
		Productivity of nesting shorebirds may increase if they are able to change their migration and nesting schedules to coincide with the time when the most insects are available.	LH	L	LLL	LLL	LLL
		Predation on ground nesting birds could increase if alternate prey (lemming) abundance declines with changes to weather and tundra habitats.	L		LL	LL	LL

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		Coastal seabirds such as the arctic Ivory Gull, Aleutian Tern, and Kittlitz's Murrelet show medium or high vulnerability to climate change due to their low reproductive potential and their reliance on marine food webs that are also threatened by climate change.	H	M	MMM	MMM	LLL
		The population cycles of birds and their prey, such as spruce budworm, will be decoupled in some Boreal areas due to warming temperatures. Populations could continue to move northward with continued climate warming.	H	H	HMM	HMM	HMM
	Wildlife - Marine Mammals	**Ice dependant Arctic marine mammals are affected by sea ice decline**, including walrus,[iii] ice seals, and polar bear. Beluga and bowhead whales may move into territory previously unavailable to them.	L		LL	LL	LL
		Harbor seals may move or decline, spending more time in the water, or using terrestrial haul outs as floating ice declines. Population recovery could be affected.	H	L	LLL	LLL	LLL
		Increased ambient sound affects marine mammals. Reduction in sound absorption and increased human vessel traffic due to receding sea ice and tidewater glaciers may affect marine mammals that rely on echolocation for communication and prey location.	H	M	MLL	MLL	LLL
		Polar bear hazards increase in coastal communities. As polar bears have increasingly difficult times accessing prey and finding appropriate shelter for reproduction and protection, they may be more likely to approach villages and encounter humans.	L		LL	LL	LL
	Wildlife – Caribou/Reindeer	**Caribou and reindeer health may be affected** by changes in temperature and precipitation patterns, increases in insects and pests known to harass caribou and reductions of succulent forage.	L	M	MLL	MMM	MLL
		Earlier green-up could improve caribou calf survival due to more forage available to females during calving and lactation.	L	?	?L	?L	?L

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		A loss in tundra plant species diversity could affect caribou and other wildlife. For example, forbs that are selectively grazed upon by caribou during lactation or lichens used as over-wintering food.	L	M	MLL	MLL	MLL
		Caribou may suffer heavy losses, if vegetation glazes over following rain-on-snow events, preventing successful feeding during cold weather.	L	H	HLL	HLL	HLL
	Wildlife - Moose	**Predicted shifts in forest community could result in less suitable habitat for caribou, but potentially increased habitat for moose** in Yukon Flats National Wildlife Refuge and similar habitats.	L	M	MLL	MLL	MLL
		Climate change could decouple timing and synchrony of birth, hindering moose calf survival.	MH	M	MLL	MLL	MLL
	Wildlife – Small mammals	**Fire may help yellow-cheeked vole populations** in the short-term, as it creates new burrowing habitat and aids in the growth of forage.	L	M	LLL	LLL	LLL
		Reduced snow cover reduces survival of voles and other subnivian species, due to increased predation and cold stresses, with changes in small and large mammal predator-prey relationships.	M	M	MLL	LLL	LLL
	Fisheries	**Marine regimes could shift from benthic (bottom) to pelagic (open water) species.** Late ice retreat supports benthic organisms. When there is no ice, or early ice retreat, a mostly pelagic ecosystem is supported.	L		LL	LL	LL
		Commercial fisheries shift. Changes in ocean community organization in the Bering Sea caused by warming climate and associated loss of sea ice alter availability of snow crab and other fisheries resources.	HL	H	HLL	HLL	HLL
		Ocean acidification affects fisheries. Pteropods and crustaceans foods of salmon may decline with ocean acidification.	H	H	HMM	HMM	HMM
		New stream habitats become available for colonization by fish and wildlife as glaciers decline.	H	H	L/MLL	LLL	LLL

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		Fish diseases such as *Ichthyophonus* increase with rising water temperatures. Models indicate that temperature increase in streams in south-central Alaska will be around 3°C, a change that could increase disease in fish.	H	H	HHLL	HHLL	HHLL
		Some existing salmon waters may become unsuitable for migration, spawning and incubation.	H	H	HLL	MLL	MLL
		Fish habitats in some permafrost-dominated areas may be degraded by thaw-related hill slumps and massive sediment input into rivers.	L	L	LLL	LLL	LLL
	Invertebrates	**Ice worm populations decline** locally as glacier habitats melt.	H	H	MLL	LLL	LLLL
		Marine intertidal environments change and may become more susceptible to exotic marine species, including green crabs.	H	M	HLL	MLL	LLL
		Exotic pests, diseases and their vectors expand into Alaska from warmer areas, and endemic pests expand as host species are stressed by climate change (e.g., bark beetles, budworms, ticks, lice, West Nile virus, Lyme disease, hantavirus, HP avian influenza, **plague, vespid [yellowjacket spp.] outbreaks, black flies, mosquito swarms, bott flies, etc.)**,	H	H	HMM	MMM	HMM
	Subsistence, Fishing, and Hunting	**Intensified management expands.** Some local residents and management agencies may advocate managing for new species that have the potential to replace diminished subsistence hunting, trapping, and fishing opportunities, and for intensified management of native species.	HM	H	HHLL	HHLL	HHLL
		Altered migration patterns make hunting more challenging. Migration patterns of terrestrial animals are predicted to change as temperatures, precipitation patterns, and vegetation availability change.	L	H	HLL	MLL	MLL

Comment [RB11]: Especially for fish/salmon

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		Marine subsistence becomes more challenging. As sea ice conditions change, hunting for marine mammals is becoming more dangerous and costly. Marine mammals may follow sea ice retreat, altering their distribution and taking them out of range for some hunters.	L		LL	LL	LL
		Community resources available for subsistence activities decline as increased storm surges, and permafrost erosion compound effects of change to relative sea level, impacting infrastructure in Native Alaskan communities, in some cases requiring relocation of entire communities.	L	H	HLL	HLL	HLL
Other Human Uses and Values	Wilderness	**Large-scale physical and biological changes across broad landscapes** affect abundance and condition of wilderness-associated resources (glaciers, tundra, boreal forest, wildlife, scenic vistas, river flows, access routes, etc.)	H	H	HLL	MLL	MLL
		The scientific community becomes increasingly interested in wilderness sites for a variety of inventories, monitoring and research projects, some of which involve highly technical instruments, mechanized access, and long-term installations.	H	H	HHH	MMM	MLL
		The changing biophysical landscape, and increased human activity to research, monitor, and respond to threats associated with climate change affect key wilderness values such as naturalness, wild-untamed areas without permanent facilities opportunities for solitude, etc.	H	H	HM	HLL	HLL
	Tourism	**Tourism expands at higher latitudes.** The effects of these changes will depend greatly on the flexibility demonstrated by institutions and tourists as they react to climate change.	M		L	L	L
		Alaska's tourism season lengthens with increasing temperatures and more snow-free days. Some visitor activities increase, while others (e.g., snow sports) may decline.	H	M	ML	L	ML
		Landscape-level changes affect visitor experiences as iconic	H				

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		scenery changes, and access for subsistence, hiking, boating, etc. changes with vegetation, soil, and water conditions. Some changes are conducive to visitation, and some are not, depending on local conditions and visitor expectations.		H	MLL	LLL	LLL
		Visitor use patterns shift as tour operators seek to provide visitors with more opportunities to experience increasingly uncommon glacier scenery. Cruise ships and day tour operators may shift some itineraries away from the parks they've traditionally visited, or seek more opportunities to shift itineraries deeper into the parks. Land based operators may press to bring groups further into the park through aircraft, airboats, snowmobile tours, off road vehicles (ORVs), and road extensions.	H	L	LLL	LLL	LLL
		Visitor demand for new interpretive/education media products, publications and services that address changing climate will increase, putting pressure on existing programs and staffing as a result.	H	MH	MHLL	LHLL	LHLL
		More cruise ships pass through the Bering Straights as ice-free conditions become more reliable.	L		L	L	LL
		Coastal tourism destinations are affected by increase coastal erosion, and losses of natural and cultural resources, natural routes of access, and built infrastructure.	L		LL	LL	LL
	Other Hazards	**Safety hazards develop, expand or are recognized in relation to climate change,** such as thin ice, erratic flooding, changing fire and smoke hazards, slope failures (mudslides, landslides, tsunami hazards), and expansion of more disease organisms (fish, wildlife, and human) and their vectors into Alaska.	H	M	HLL	LLL	MLL
	Customary and Traditional	**The predictive uses of traditional ecological knowledge will change**, as unprecedented changes develop for weather, freeze/thaw	LH	H	ML	ML	ML

Comment [RB12]: Timing of salmon runs may change due to water temp's and flows

Sector	Subsector	Potential Effects to Resources, Operations, and People	Affected Arctic Alaska Parks				
			KEFJ	LACL	KATM	ANIA	ALAG
	Knowledge	conditions, plants, animals, fire, etc.					
	Resource and Economic Development	**Natural resource development and economic activities expand in Alaska** with increasing global demand for energy and resources to supply rising global population.	LHM	MH	MHHH	MHM	MHM M
		Developmental pressures increase as direct or indirect effects of reduced snow and ice cover. These include expanded global and regional transportation systems and their associated infrastructure (e.g. opening of the Northwest Passage due to reduced sea ice, permanent roads to replace ice roads), increased demand for natural resource development (construction materials – especially gravel and rock, energy and minerals for infrastructure repair, replacement, and expansion), shifting agricultural production zones, community resettlement and other population shifts.	HM	H	HLL	HLL	HLL
		Infrastructure development expands along Alaska's coasts and Interior to provide needed services, facilities, and transportation systems for other expanded activities.	LM	MH	LHLL	LHLL	LLL
		Damage to roads, buildings, and other infrastructure increases due largely to permafrost thaw (but also from storms, floods, and landslides) adding 10% to 20% by 2080.	H	M	MLL	LLL	LLL
		Relocating indigenous communities represents a large social burden, not just financial cost for governments, but also impacts the communities themselves, potentially resulting in loss of integral cultural elements such as access to traditional use areas for subsistence activities, loss of history and sense of intact community, and potential loss of social networks and extended kin support. Significant increases in social pathologies such as alcoholism and domestic violence may be anticipated. In addition, tremendous stresses will be placed on	L	HM	MMLL	MMLL	MMLL

Comment [RB13]: Possible oil and gas in Bristol Bay region

Sector	Subsector	Potential Effects to Resources, Operations, and People	Affected Arctic Alaska Parks				
			KEFJ	LACL	KATM	ANIA	ALAG
		traditional means of conflict resolution. In addition multiple strains will be placed on local governance and delivery of services. Finally, state and federal governments will have huge additional burdens placed on them as they try to provide relief from the impacts of climate change (flooding, destruction of infrastructure, high demands placed on social services and so forth). Response to climate change will require enormous pressures for integrated and efficient bureaucratic structures.					
		Fuel and energy prices increase substantially as carbon mitigation measures are implemented (sequestration, carbon caps, offsets, etc.). Costs of transporting fuels to remote locations by barge, ice roads, aircraft, etc. also becomes more challenging and costly.	M	H	HHH	HMM	HMM

[i] Increased logging could contribute to CO2 sequestration where wood is put into structures and preserved and new trees grow to replace the removed trees.
[ii] Some glaciated coasts are overwhelmed by plate tectonics, such as the subduction zone along the west shores of KEFJ where we have drowned cirques. As ice melts, rebound may be overtaken by subduction. The opposite may be true where we have up-thrust zones, such as along the Cook Inlet side of the Kenai Peninsula and perhaps along the LACL coast.
[iii] Narwhals do not occur in AK, so let's delete this here. Other marine mammal species may be affected with sea ice changes such as beluga and bowhead whales, who may benefit.